# Autonomous Vehicles Educational Forum

## AGENDA

| | |
|---|---|
| 7:00-7:10 | Town of Arlington – Introduction and Welcome |
| 7:10-7:30 | What are Autonomous Vehicles? |
| 7:30-7:50 | Potential Impacts to Public Infrastructure and Land Use |
| 7:50-8:10 | Potential Fiscal and Economic Impacts |
| 8:10-8:25 | Question and Answer Period |
| 8:25-8:30 | Town of Arlington – Closing Remarks |

Arlington Town Hall Auditorium
November 14, 2017
7:00 PM – 8:30 PM

U.S. Department of Transportation
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# Autonomous Vehicles Educational Forum

Scott Smith, Senior Operations Research Analyst
Volpe Center/ U.S. Department of Transportation

Eric Bourassa, Transportation Director
Metropolitan Area Planning Council

Rafael Mares, Vice President and Director, Healthy Communities and
Environmental Justice, Conservation Law Foundation

Arlington Town Hall Auditorium
November 14, 2017
7:00 PM – 8:30 PM

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# Agenda

- ❑ What are automated vehicles?
- ❑ When will automated vehicles be on our roads?
- ❑ What are their potential impacts?

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# Disclaimer

Statements made during this presentation are opinions of the speaker and do not represent official positions of the U.S. Department of Transportation.
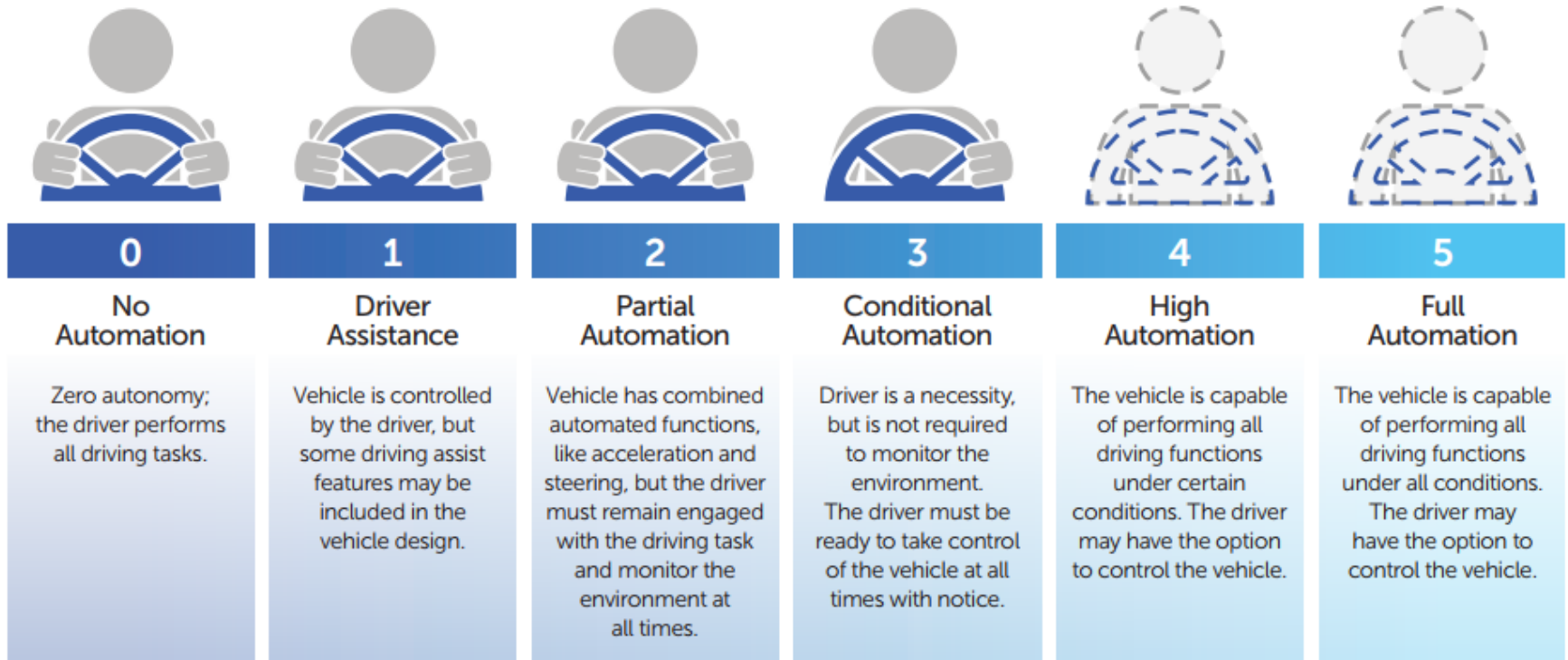
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# What are automated vehicles?

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# What are automated vehicles?

# Varying levels of automation (SAE J3016)

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **No Automation** | **Driver Assistance** | **Partial Automation** | **Conditional Automation** | **High Automation** | **Full Automation** |
| Zero autonomy; the driver performs all driving tasks. | Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design. | Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times. | Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice. | The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle. | The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle. |

*Adapted from SAE J3016 Standard*

**Automated Driving Systems (ADS)**

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# How do automated vehicles work?

❑ Sensors
   ▪ Radar
   ▪ Cameras
   ▪ Lidar
   ▪ Ultrasonic
   ▪ Infrared

❑ Sensor data may be combined with other data inputs:
   ▪ Highly detailed mapping data
   ▪ V2V/V2I Messages

❑ Automated image processing
   ▪ Feature extraction
   ▪ Machine vision

❑ Machine Learning/Artificial Intelligence
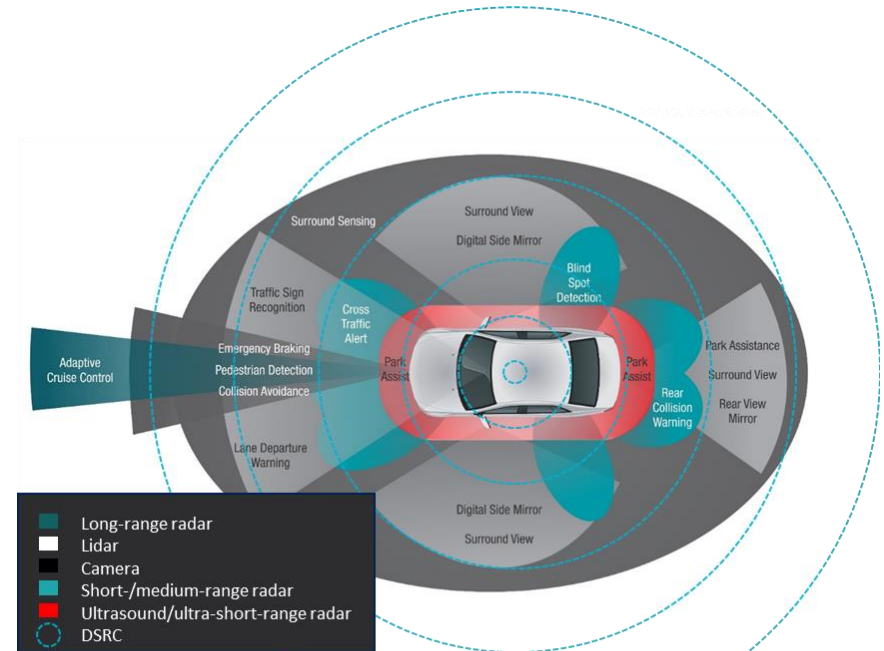   ▪ Based on what an AV can "see" and what it predicts nearby objects are likely to do, it can make decisions about speed and steering inputs



Legend:
- Long-range radar
- Lidar
- Camera
- Short-/medium-range radar
- Ultrasound/ultra-short-range radar
- DSRC

*Image Adapted from the Texas Instruments ADAS Solutions Guide*
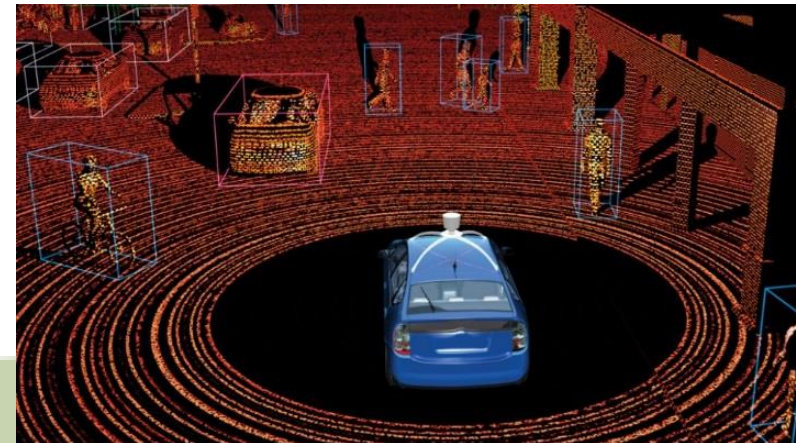


*Image Source: Popular Science*

# When will automated vehicles be on our roads?

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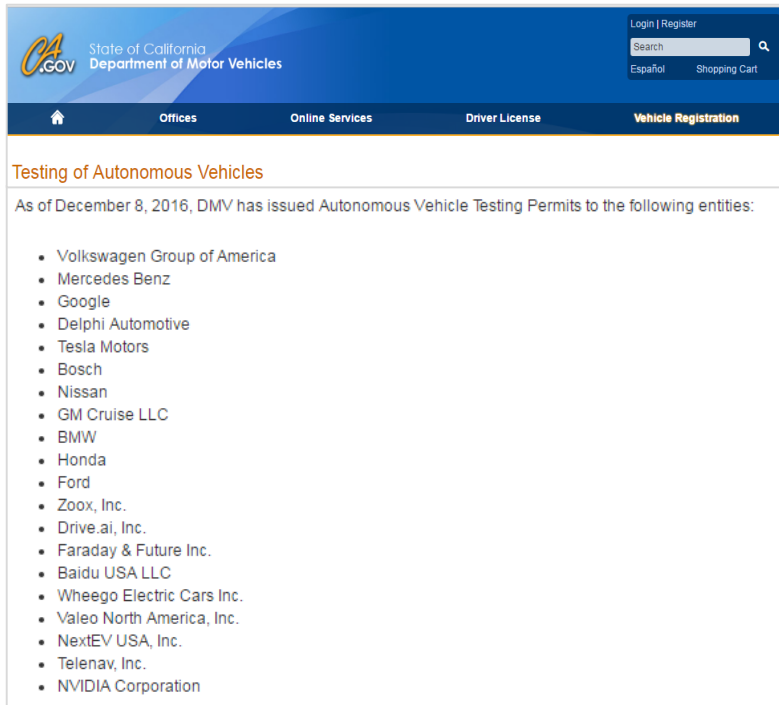
# Automated vehicles are...here today
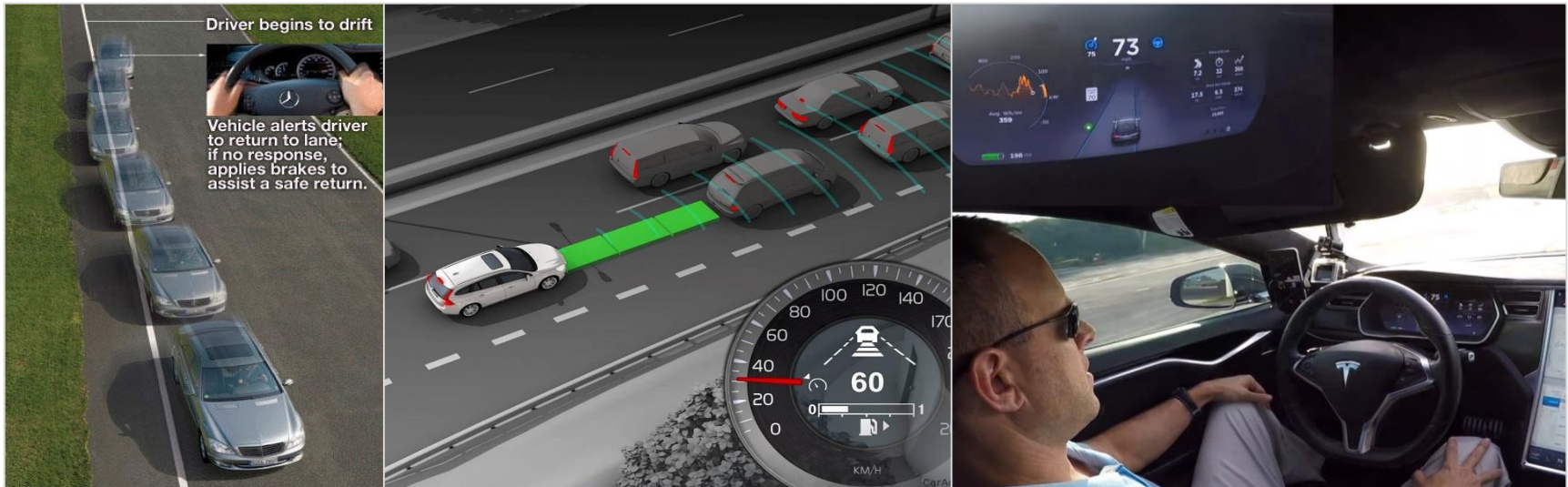


❑ Most major manufacturers currently offer Level 1 systems (e.g., lane keep assist, adaptive cruise control)

❑ Some offer Level 2 systems (e.g., Tesla Autopilot, Audi Traffic Jam Assistant)

*Image Sources (left to right): Mercedes-Benz, Volvo, The Verge*

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# Automated vehicles are…in testing



Image Sources (left to right, top to bottom): Uber, Google, Otto, Local Motors

❑ Dozens of manufacturers and technology companies are currently testing AVs

❑ They are not only testing passenger vehicles, but also heavy duty commercial and small transit-like vehicles

# Automated vehicles are…in testing



States with Enacted Autonomous Vehicle Legislation

LEGEND
Enacted
Executive Order

AS  GU  MP  VI  PR

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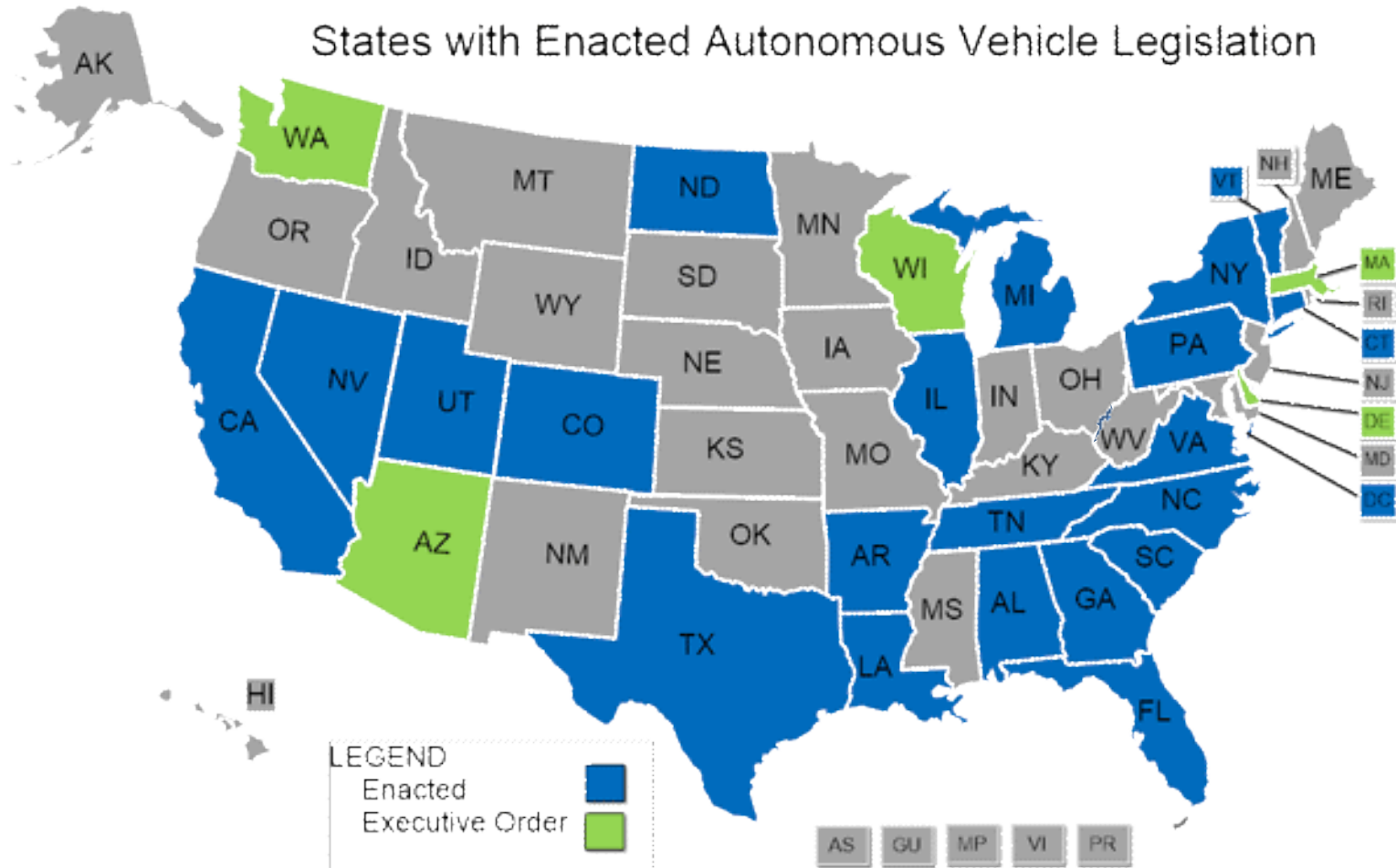
# Automated vehicles are…coming soon

**GM will test fully autonomous cars 'in quarters not years,' CEO Mary Barra says** – CNBC, 24 October 2017

**BMW says self-driving car to be level 5 capable by 2021** - Reuters,16 March 2017

**Ford's self-driving car 'coming in 2021' –** BBC 17 August 2016

**Toyota to test self-driving, talking cars by about 2020 –** Reuters, 16 October 2017

**Navya driverless shuttles to begin ferrying University of Michigan students this fall** – Techcrunch, 21 June 2017

**Arlington (Texas) to Roll Out Milo Autonomous Shuttle Pilot Program August 26, 2017**

❑ **Many manufacturers are targeting 2020 (or potentially sooner) to introduce Level 3 and 4 automated vehicles…**

# But…
# adoption timelines are a moving target

## 1957



**America's Independent Electric Light and Power Companies
1957 advertisement (image of the future in 10 years)**

# But…
# it takes decades for the fleet to turn over

### Expected Survival Rate of Model Year 2017 Passenger Cars
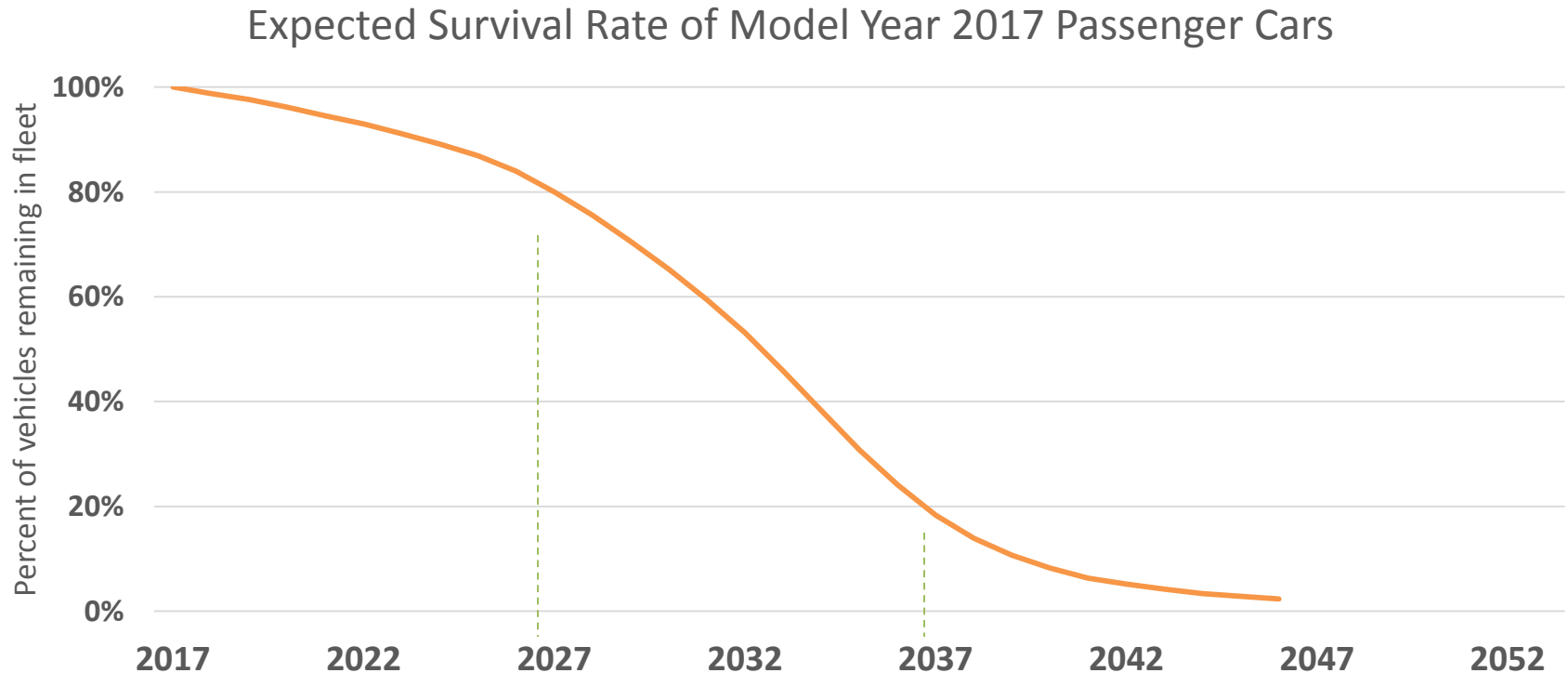


☐ **Cars on our roads today are an average of 11.4 years old and it can take close to 30 years for the fleet to completely turn over**

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# Different approaches to automation
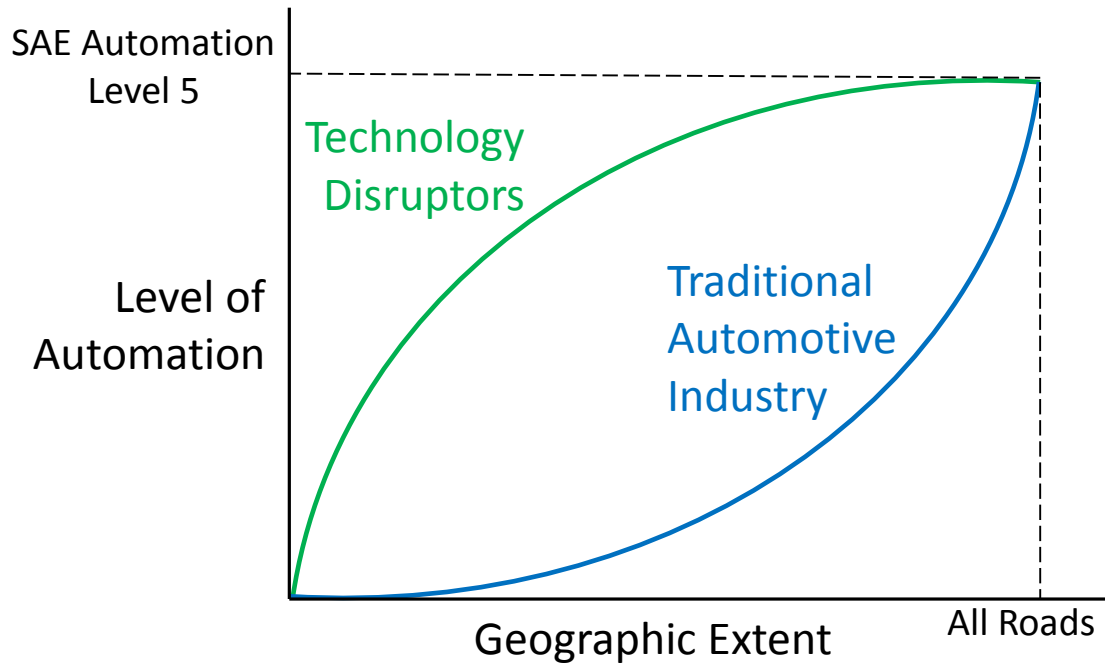


**Highly automated vehicles (L4) operating in a limited geographic extent**

**Increasingly sophisticated driver assistance functions (L1), moving towards partial automation (L2)**

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# How will automation impact us?

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# Potential benefits and significant uncertainty

| Impact Area | Potential Benefit | Potential Dis-Benefit |
|---|---|---|
| Safety | Reduction in crashes | New types of crashes |
| Personal Mobility | More options, especially for those unable/unwilling to drive Potentially cheaper | Can *everyone* access the automated vehicles? |
| Energy Use and Pollution | Smoother speed profiles, platooning, light-weighting could improve efficiency | Increases in VMT could increase fuel use/pollution |
| Network Efficiency | May increase throughput | May increase congestion, via increased trips |
| Public Health | Improved access to medical care, work and recreation for non-motorists | May reduce use of active modes |
| Travel Behavior and Vehicle Ownership | May decrease need for ownership, potentially reducing fleet size | May lead to more trips, with ability to safely multi-task enroute |
| Land Use | May encourage density by freeing up space currently devoted to parking | May encourage sprawl |

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# Areas of uncertainty
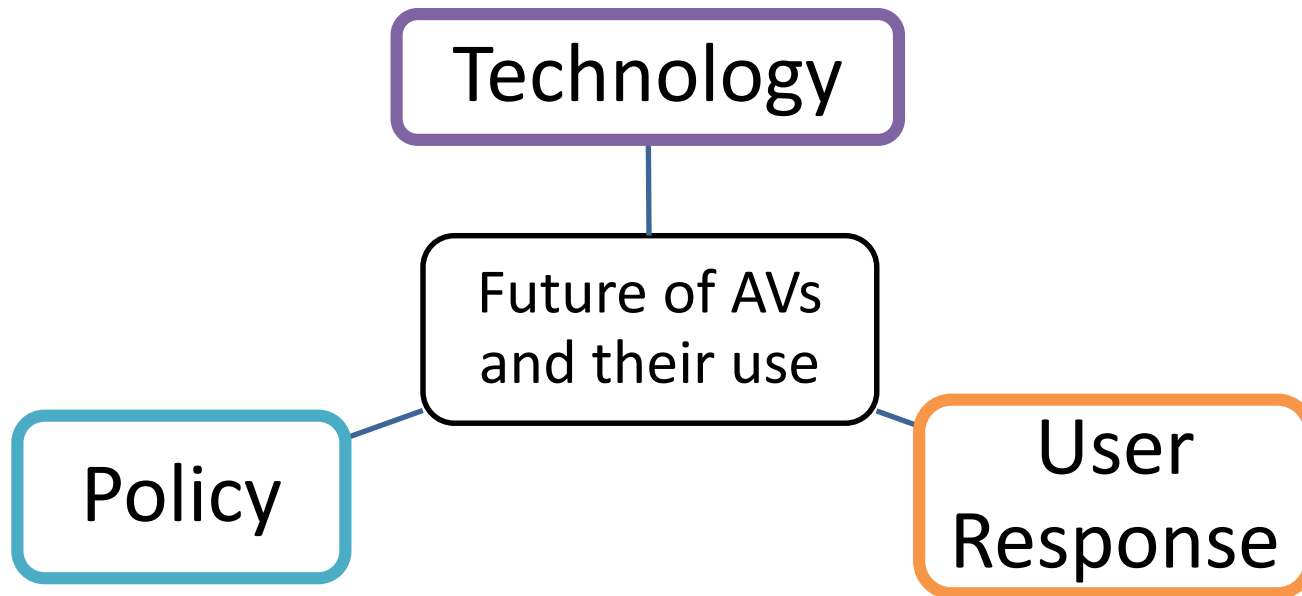
# USDOT voluntary guidance

- *Automated Driving Systems 2.0: A Vision for Safety* released in September 2017.

- Replaces 2016 Federal Automated Vehicles Policy

- More information available on NHTSA website: https://www.nhtsa.gov/technology-innovation/automated-vehicles



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# For more information

**Scott Smith**

Technology Innovation and Policy Division

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www.volpe.dot.gov
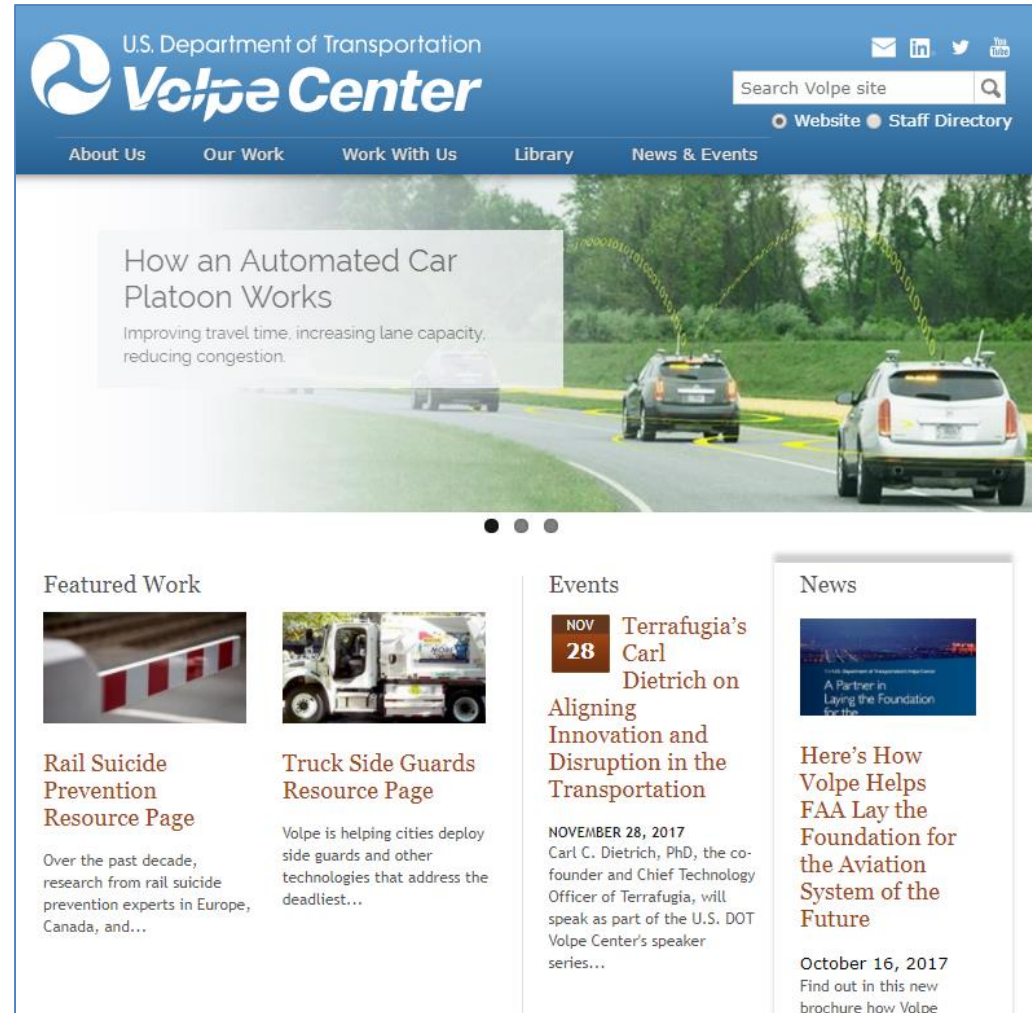
# Autonomous Vehicles Educational Forum

Eric Bourassa, Transportation Director
Metropolitan Area Planning Council

➢ Adoption of New Technologies Can be Rapid

➢ Testing Today in Boston

➢ Planning and Policy Considerations

# Automobile Influence on Land Use

Outside of Clinton
Source: Wikimedia – Nick Allen

Wellesley Office Park
Source: Bing

Route 1, Saugus
Source: Bing

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# Where is the Car?

1900
New York
City
5th Avenue

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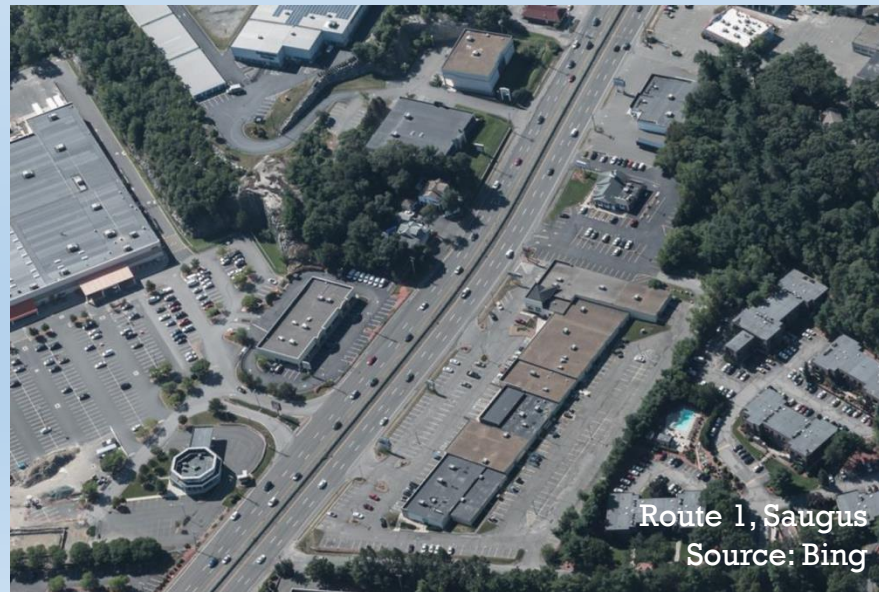
# Where is the Car?

**1900 New York City 5th Avenue**



Source: National Archive: https://www.archives.gov/files/research/american-cities/images/american-cities-101.jpg
Inspiration from Tony Seba's lecture, Clean Disruption of Energy & Transportation, 2017

# Where is the Horse?

1913
New York
City
5th Avenue

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# Where is the Horse?



1913
New York
City
5th Avenue

Source: http://www.shorpy.com/node/204
Inspiration from Tony Seba's lecture, Clean Disruption of Energy & Transportation, 2017

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# Adoption Rate
# of New Technologies Can be Rapid
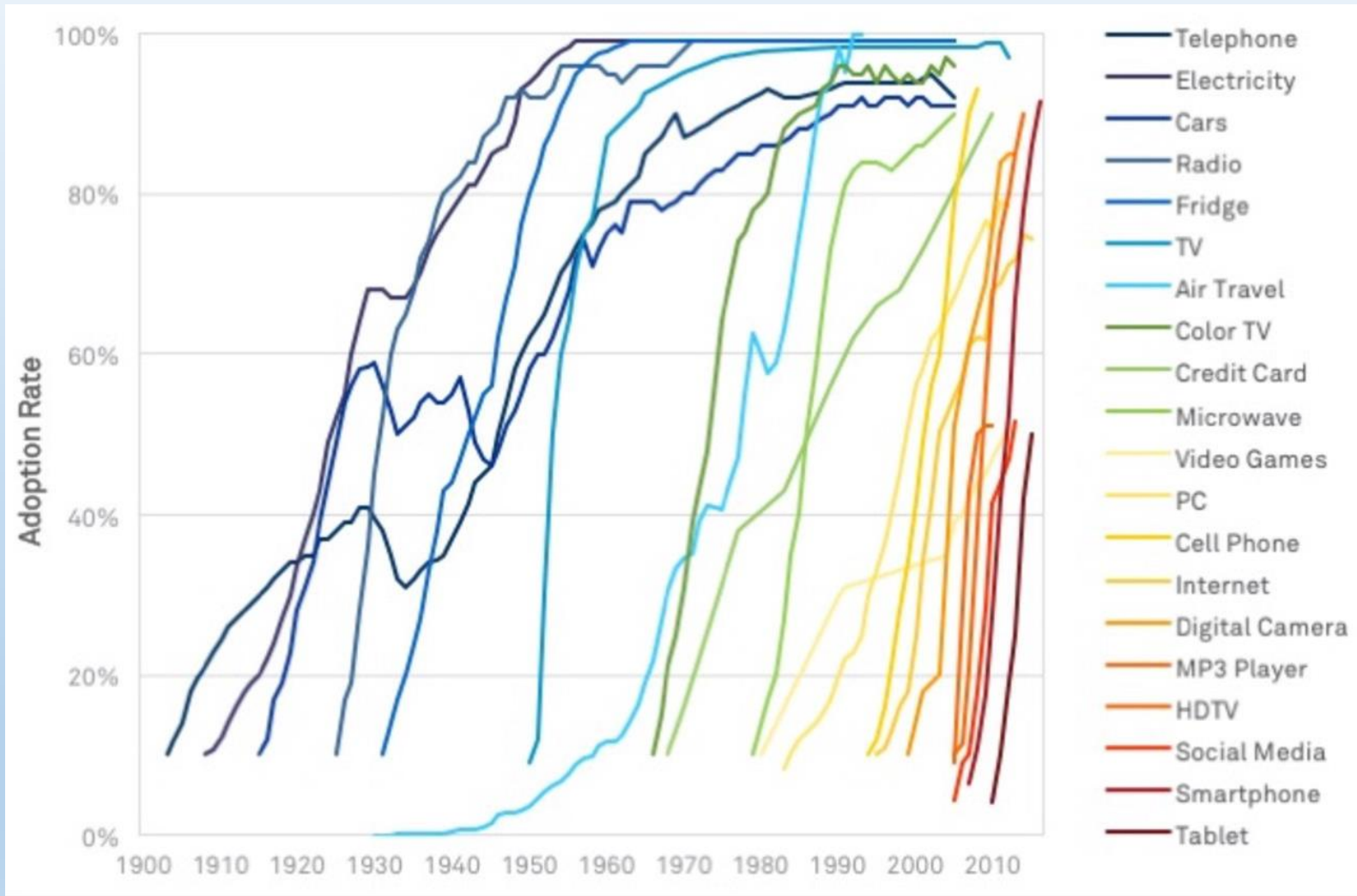


Source: Asymco

# Autonomous Vehicle Testing in Boston

## Testing Sites



Source: Kris Carter, Mayor's Office of New Urban Mechanics, City of Boston

## Testing Phases

**A** — *Off-site testing*

**B1** — *100 miles, Marine Industrial Park, day time only, good weather*

**B2** — *100 miles, Marine Industrial Park, day and night time, mixed weather*

**C1** — *200 miles, South Boston Waterfront, day time only, good weather*

**C2** — *200 miles in South Boston Waterfront, day and night, mixed weather*

**D1** — *400 miles in City of Boston, day time only, good weather*

**D2** — *City of Boston day and night time, mixed weather*
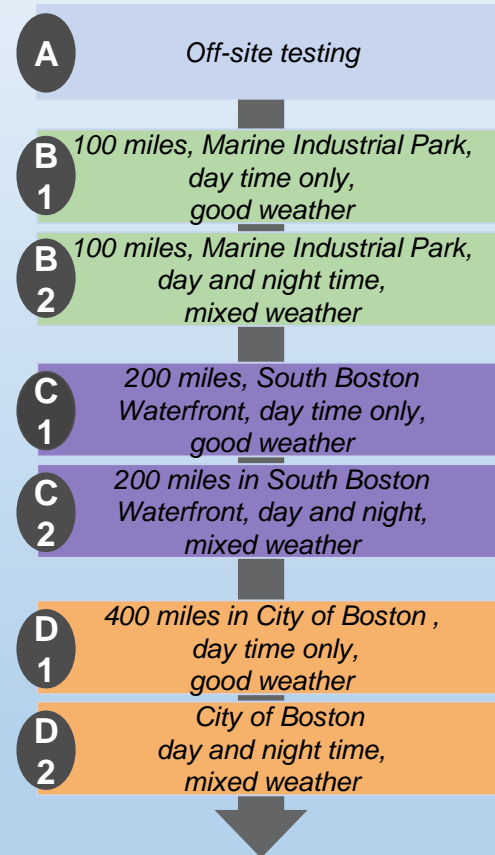
# Autonomous Vehicle Testing in Boston

**nuTonomy**

**Renault Zoe**

C 3 — *200 miles in South Boston Waterfront, day and night, mixed weather, with passengers*

**OPTIMUS RIDE**

**Polaris GEM e4 and e6**

B — *100 miles, Marine Industrial Park, day time only, good weather*

**DELPHI**
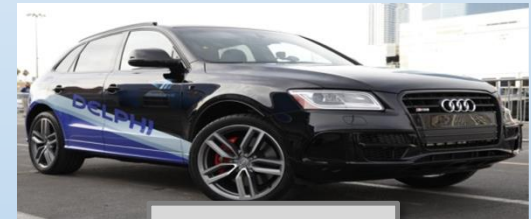
**Audi Q5**

B 2 — *100 Miles, Marine Industrial Park, night-time and light rain*

**merger occurring**

Source: Kris Carter, Mayor's Office of New Urban Mechanics, City of Boston

# Transportation as a Service

➢ Instead of consumers owning the asset (car, bike, bus) a third party provides it for a small fee.

➢ New business models dependent on smart-phone technology.

➢ Standardized and simplified payment methods.

➢ Can combine public and private transportation providers through a unified system.

➢ Example Services: ride hailing, car sharing, bike sharing, transit route planning, instant home delivery, parking applications.

➢ Example Companies: Uber, Lyft, Zipcar, Hubway, Instacart, GrubHub.

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# Convergence of Technologies
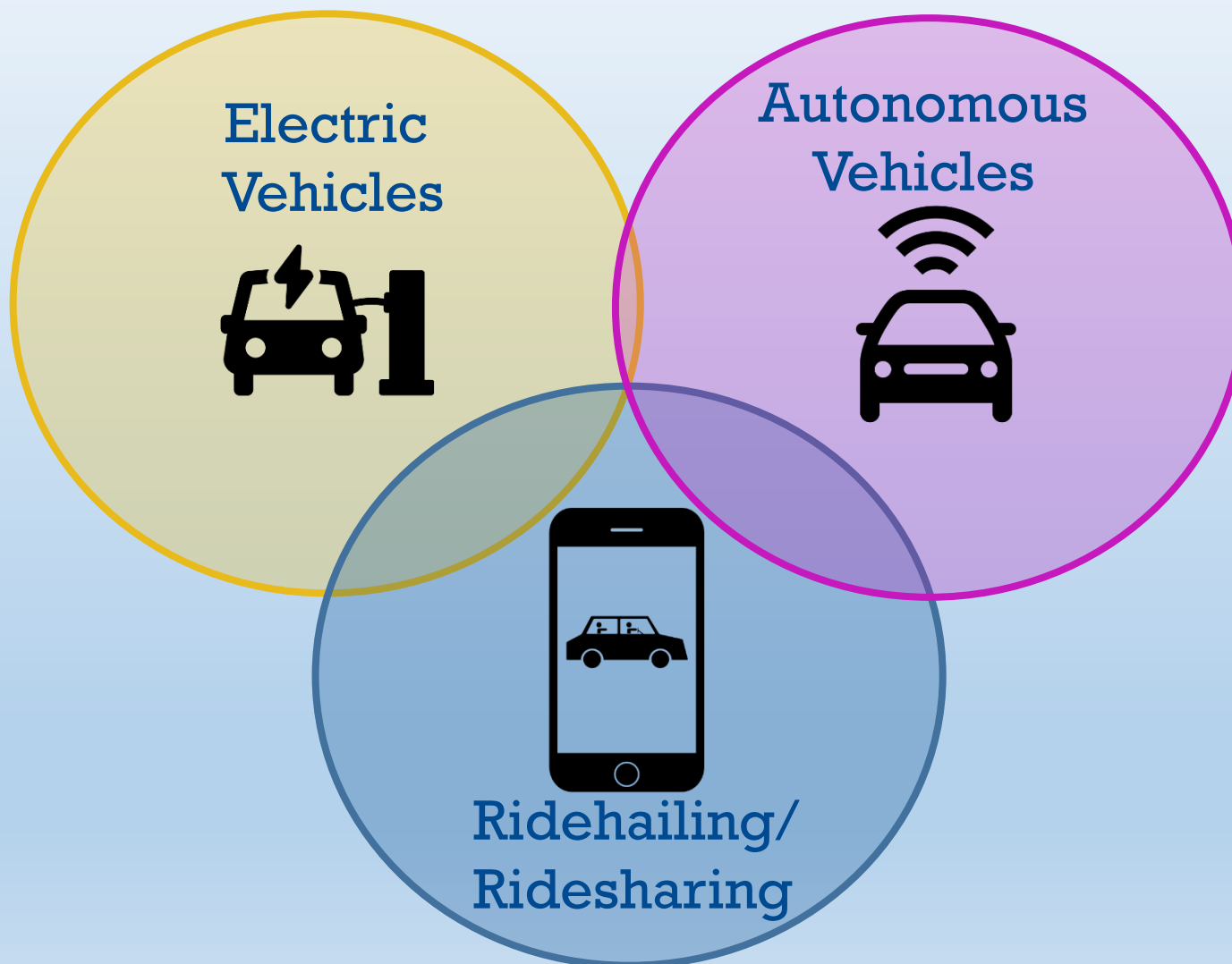
# Growth in Ridehailing

## Boston Region

➢ Uber arrived in Boston in 2011, followed by Lyft in 2013.

➢ Number of trips with Uber exceeded 115 million between 2012 and 2015.

➢ Approximately 70,000 trips between Friday and Saturday in Boston
from10:00 PM to 4:00 AM.
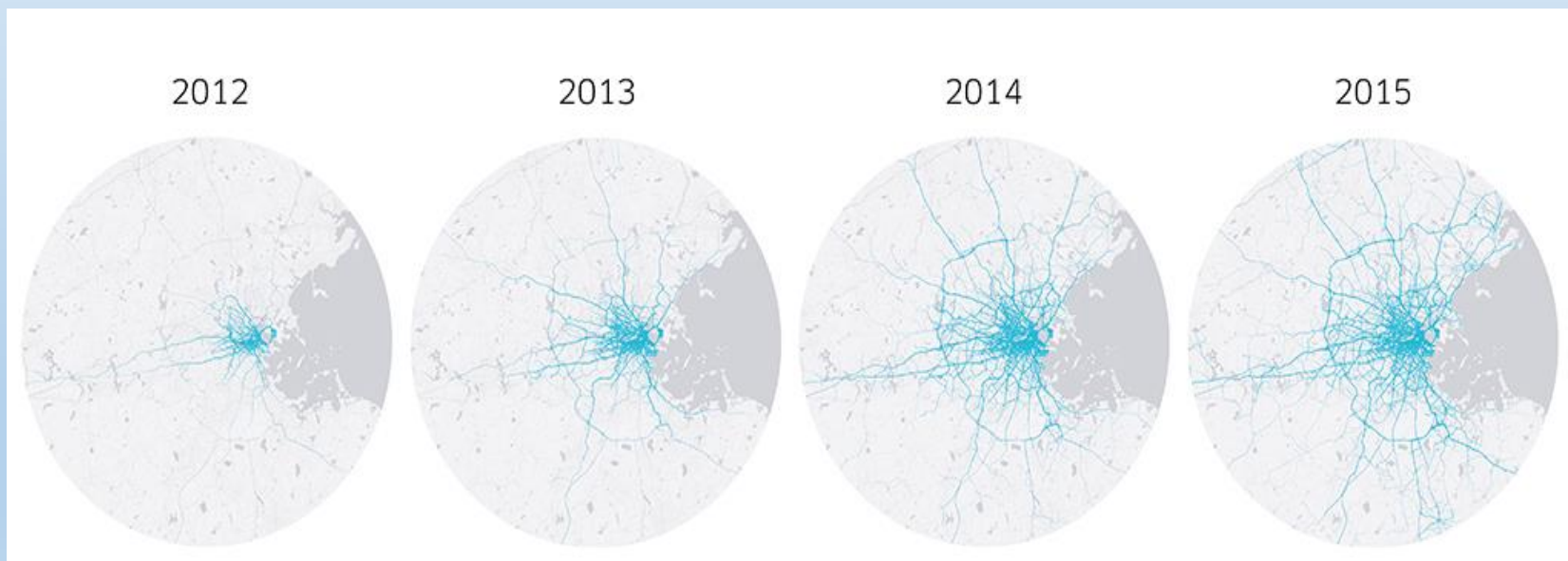


Source: Uber

# Rate of Ridehailing

## New York City

➢ Ridehailing tripled between June 2015 and Fall 2016.

➢ Added 600 million miles of travel between 2013 and 2015.

## San Francisco

➢ On a typical weekday, there are more than 170,00 vehicle trips within San Francisco, representing 15% of all intra-city vehicle trips in 2016.

➢ At peak periods, ridehailing trips are estimated to comprise 20-26% of vehicle trips in downtown areas in 2016.

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# Critical Areas for State and Local Government Planning

**Regulatory Framework**
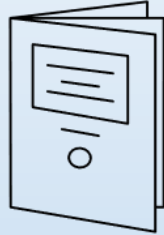
**Infrastructure**
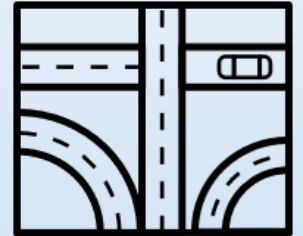
**Data**

**Parking**

**Land Use Impacts**

**Coordination**

# Ways Autonomous Vehicles Could Change the Transportation Landscape
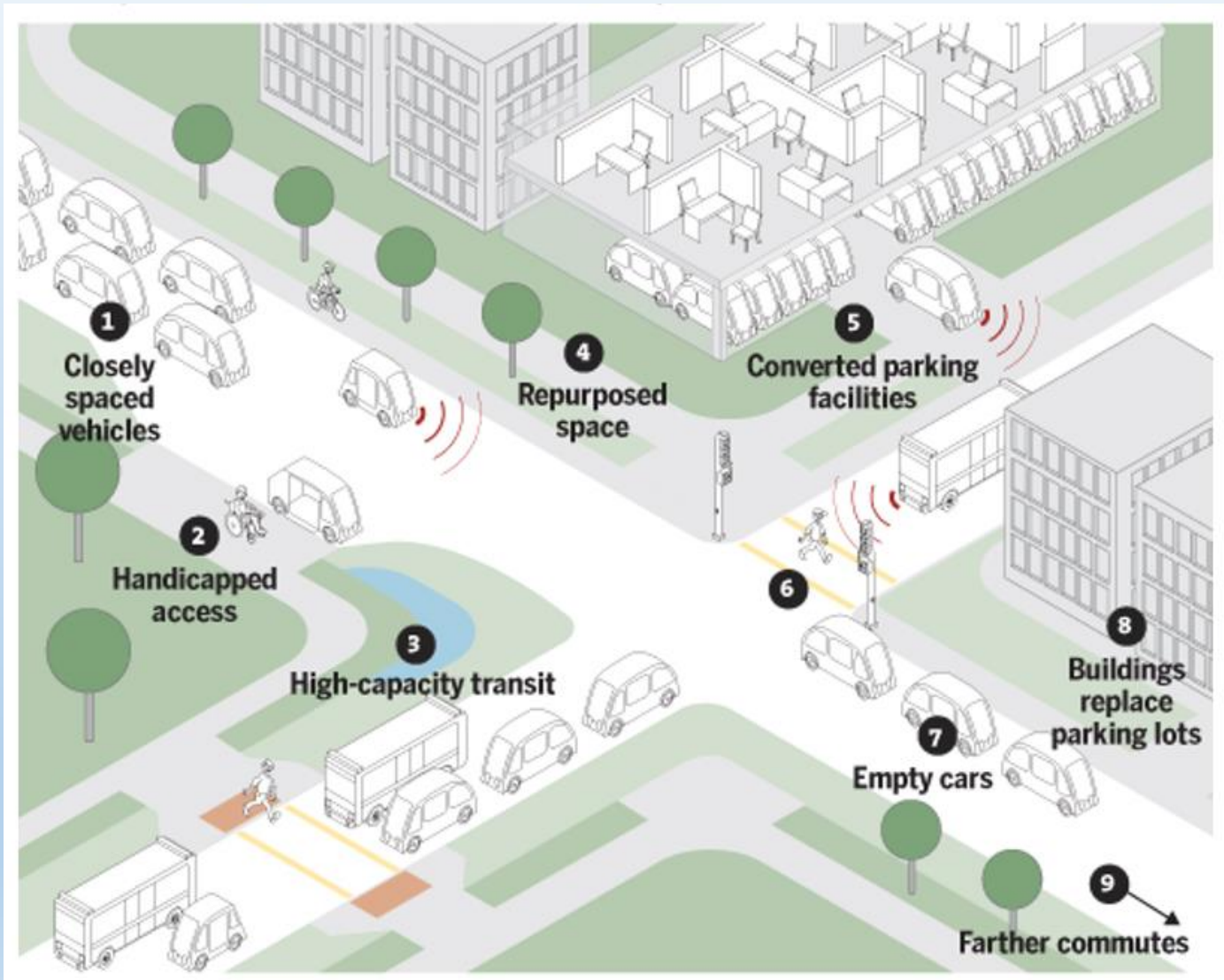


Source: MIT Senselab

# Imagining Future Places



**Enhanced Bicycle and Pedestrian Access**

**No Permanent On-Street Parking**

**Flexible Spaces for People, Not Cars**

Source: Making Better Places: Autonomous Vehicles and Future Opportunities WSP|Parsons Brinckerhoff

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# Imagining Future Places



Figure 3.2 - Redeveloping Surface Parking into Commercial Infill Development: In a fully AV world, large surface parking lots may be redeveloped into better uses such as commercial space, as shown here, or parks and public space.

BEFORE

**Redevelop Surface Parking to Infill Development and/or Parks and Public Space**

DROP OFF LANE

AFTER

Source: Envisioning Florida's Future: Transportation and Land Use in an Automated Vehicle World

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# Arlington Center
# Parking Regulations and Supply



Off Street 496 Spaces
On-Street 1,147 Spaces
**TOTAL**
**1,643 spaces**
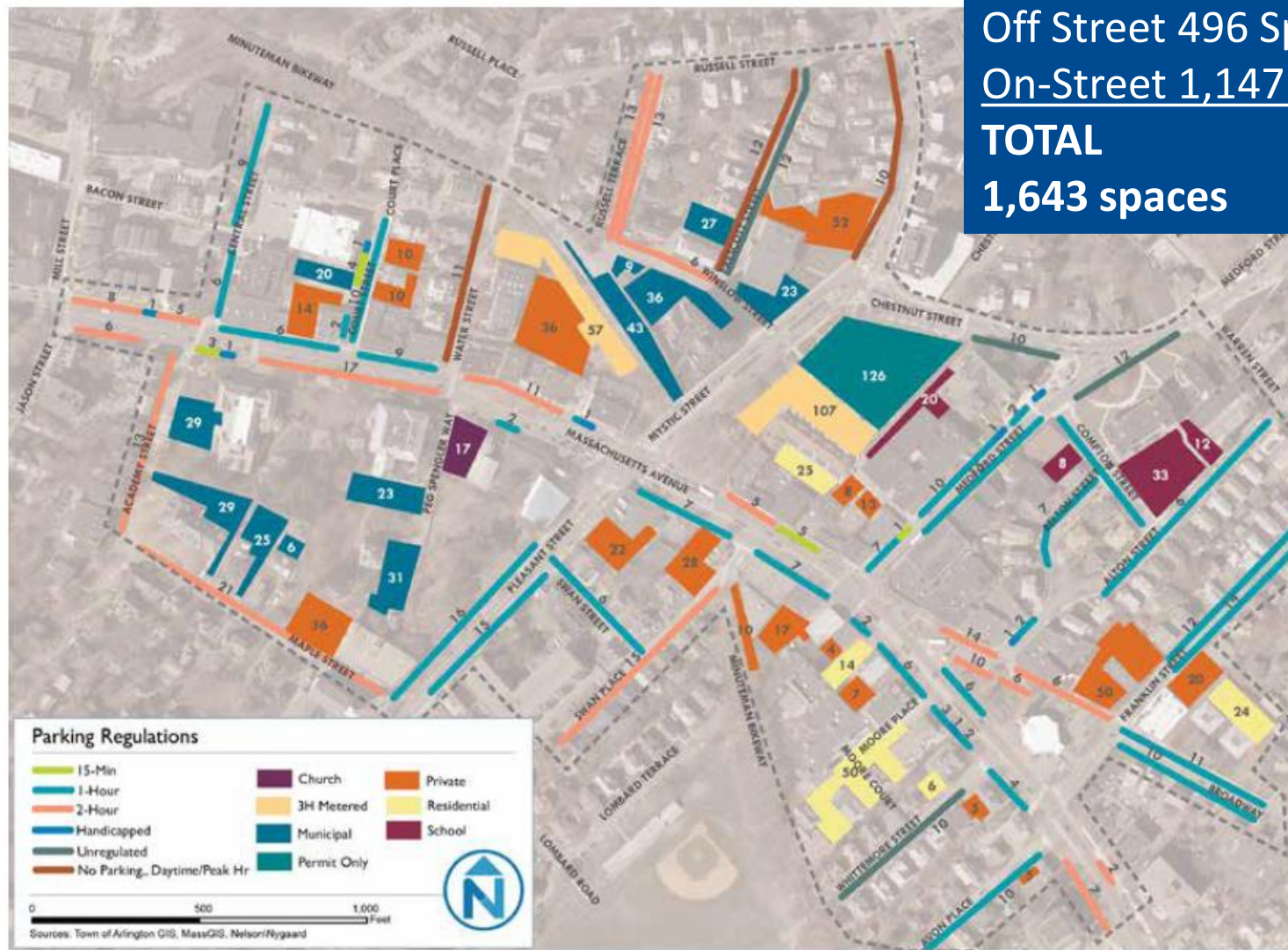
Source: Arlington Center Parking Study, Nelson Nygaard, May 2014

# Gas Stations in Arlington

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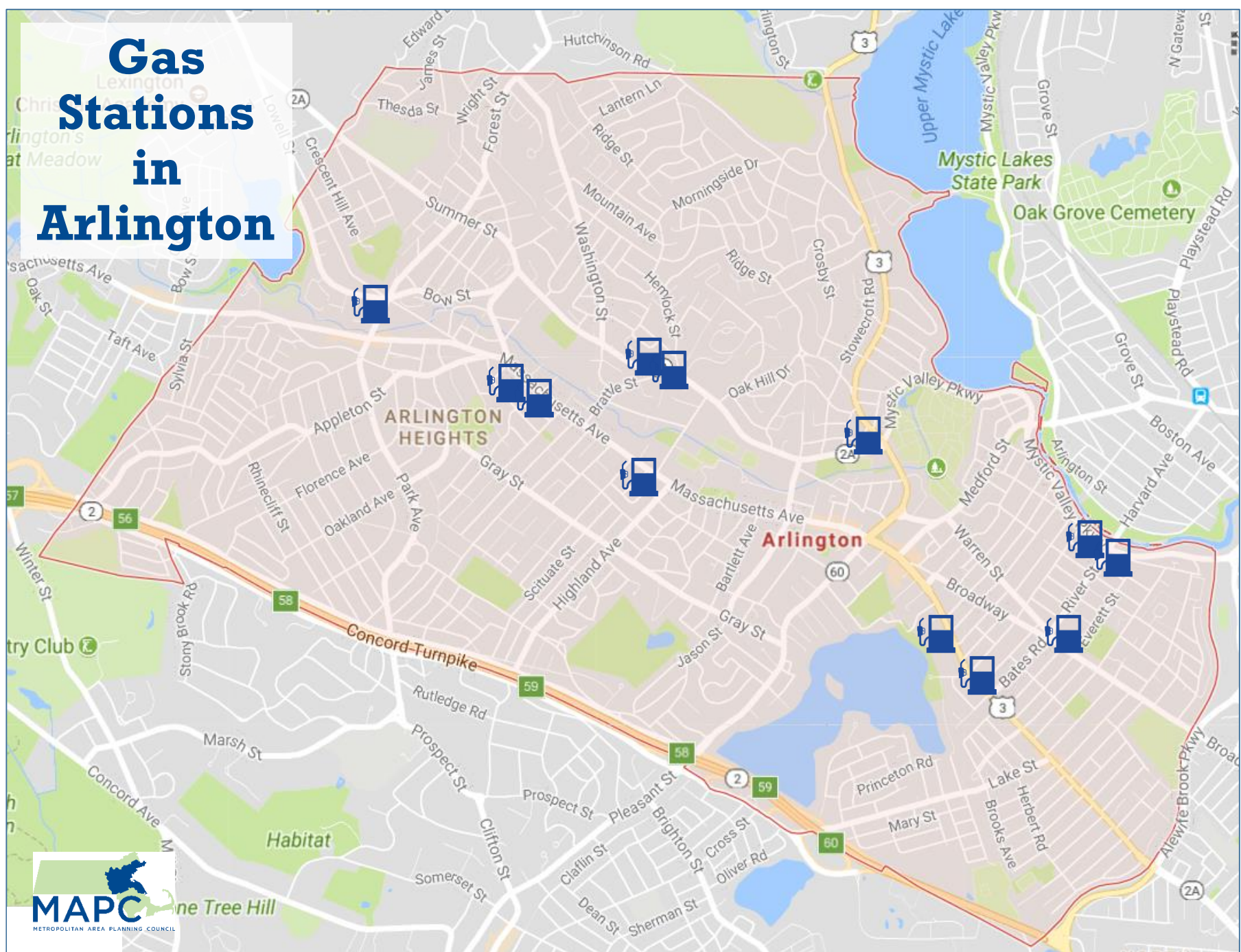
Transportation Mode to Work for Arlington Residents
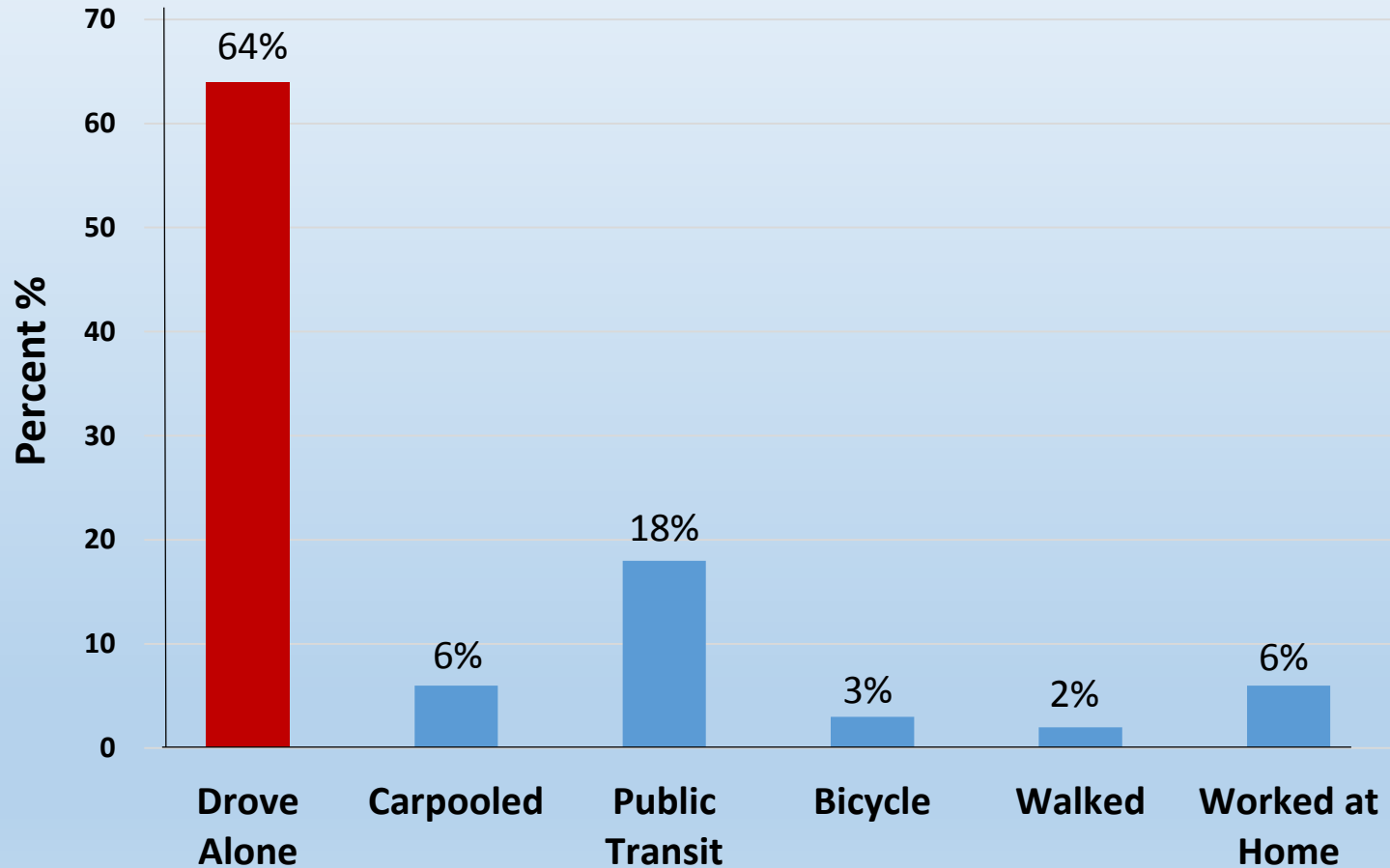
Source: US Census Data – American Community Survey - 2015

# Where is the Car?

**1900
New York
City
5th Avenue**

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# Autonomous vehicles Educational forum

## *Will self-driving cars also drive your budget?*

*The Fiscal and Economic Impacts of Autonomous Vehicles*

November 14, 2017

Rafael Mares
Vice President & Program Director
Healthy Communities and Environmental Justice

# Today's Road Map

**Municipal Budgets**
Current Motor Vehicle Revenue Sources.

**State Budgets**
Current Motor Vehicle Revenue Sources.

**Trends**
AV Budget Drivers.

**Projected Fiscal Impacts**
AVs and Municipal Revenue Sources.
AVs and State Revenue Sources.

**Projected Economic Impacts**
The costs and benefits of AVs.

**Lessons Learned**
What we have learned along the way.

**Recommendations**
Policies that can help us benefit from AVs.

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## Excise Tax:

$25 per thousand is assessed annually upon the value of the vehicle by the community where the motor vehicle is customarily garaged.

## Fines:

Moving Violations

## Parking:

🚗 Street Parking
🚗 Parking Permits
🚗 Parking Violations

CURRENT STATE OF REVENUE SOURCES

Moving Violation: speeding tickets. ($24M)

Fuels Tax: gas tax, special fuels (diesel), etc. ($756M)

Revenue Sources for FY 2015

Motor Vehicle Sales Tax: 6.25% of sales (or book price value) ($789M)

RMV Fees: License, title, and registration fees. ($511M)

Tolls: Metropolitan Highway System and Western Turnpike ($427M)

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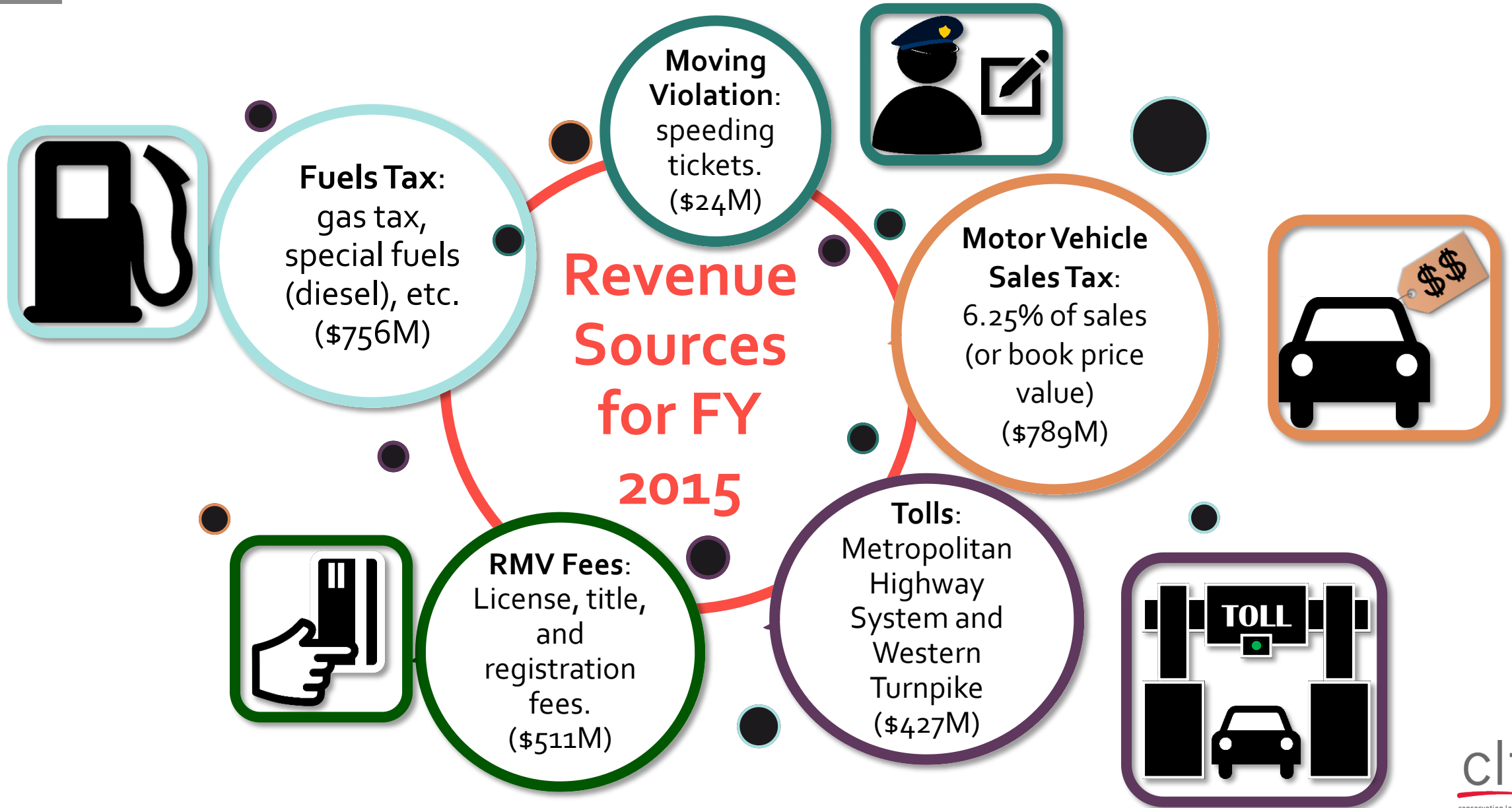
# Trends: AV Budget Drivers

**Traffic:** studies estimate VMT increase of 37% to 90%.

- Accessibility to non-drivers
- Increased willingness to travel longer distance
- Diversion from the MBTA
- Zombie vehicles
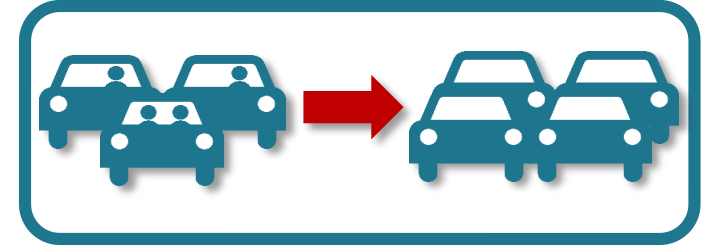
**Parking:** reduced need for parking.

- AVs can park closer together and let each other out.
- AVs can circle the block or drive home.
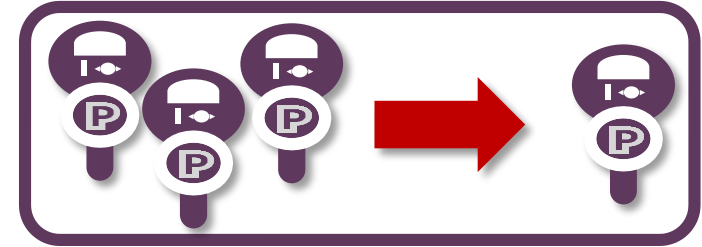
**Zero-Emissions Vehicles:** introduction of electric AVs.
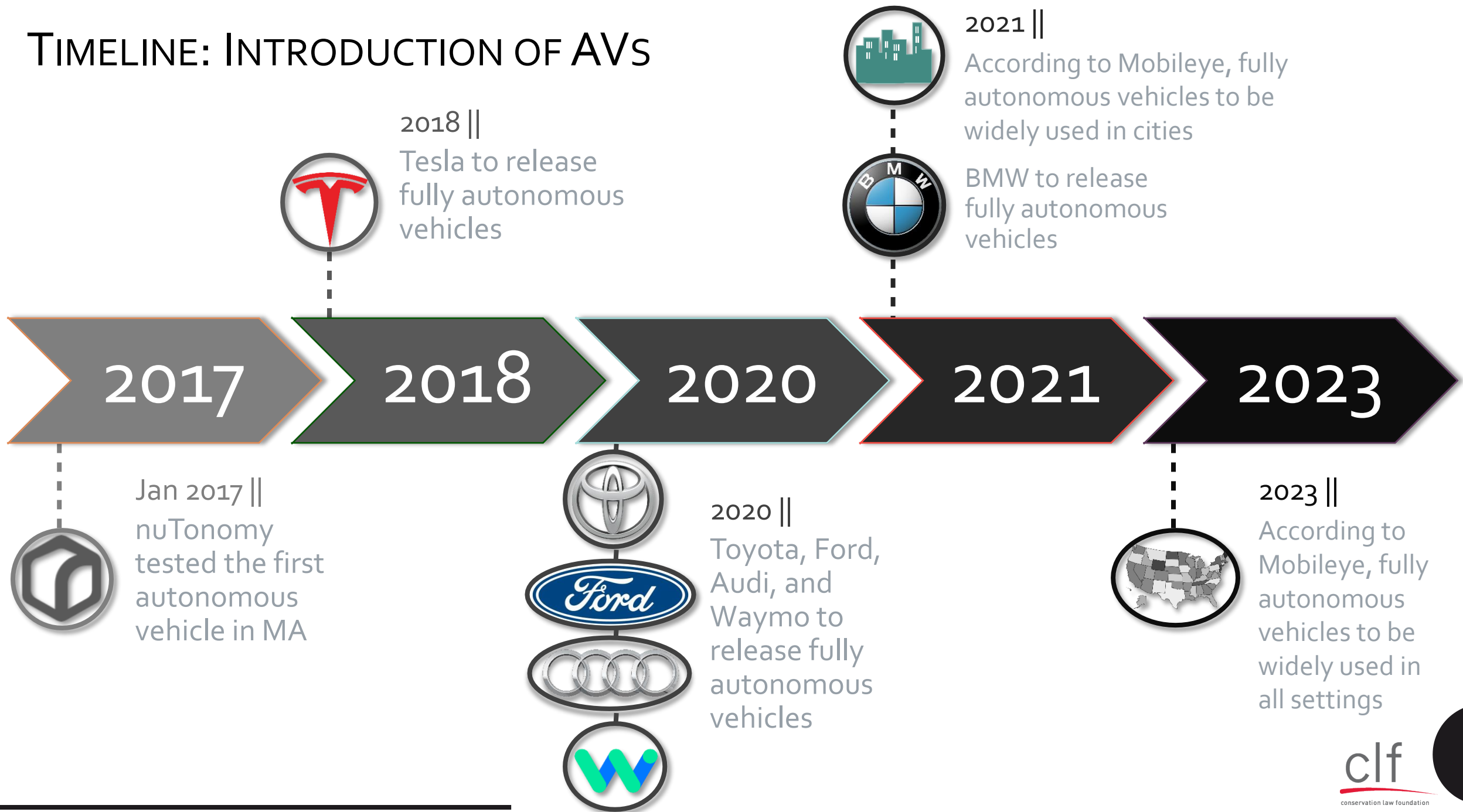
- MA Goal: 300,000 vehicles by 2030
- Currently: 11,000 ZEVs

**Sharing:** introduction of ride-sharing (v. ride-hailing).

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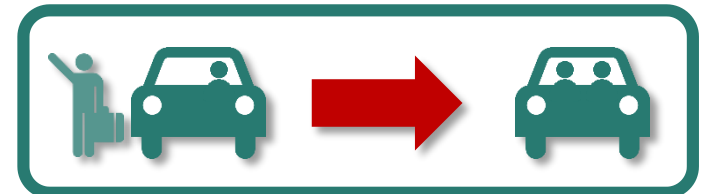
# TIMELINE: INTRODUCTION OF AVS

**2021 ||**
According to Mobileye, fully autonomous vehicles to be widely used in cities

**2018 ||**
Tesla to release fully autonomous vehicles

BMW to release fully autonomous vehicles

**2017**     **2018**     **2020**     **2021**     **2023**

**Jan 2017 ||**
nuTonomy tested the first autonomous vehicle in MA

**2020 ||**
Toyota, Ford, Audi, and Waymo to release fully autonomous vehicles

**2023 ||**
According to Mobileye, fully autonomous vehicles to be widely used in all settings

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**Overall:** Parking revenue will decline.

**Urban:** Short-term loss; long-term balance
- Major sources of motor vehicle-related revenue are street parking and parking fines (52 to 60%).
- Boston and nearby cities will see significant decline (e.g., $35M or 27% of motor vehicle-related revenue in Boston at 20% market penetration).
- After high penetration of AVs, opportunities for increase in property taxes because fewer parking garages will be needed.

**Rural/Suburban:** Less impact expected, because parking revenue is small (3% to 15%) compared to urban municipalities.

# PROJECTED IMPACT: AVS AND MUNICIPAL REVENUE SOURCES

**Overall:** Excise tax largely dependent on private ownership rate.

↑ AVs will be more expensive in the beginning (but this impact will largely disappear as additional costs of technology decline).

↓ If more AVs are used in ride-sharing (but would be balanced out partially due to larger turnover of vehicles).

↑ If more AVs are owned privately or used for ride-hailing (could impact different municipalities differently).

**Urban:** Excise tax is smaller source of motor vehicle-related revenue (40% to 48%), but greater expectation that AVs will be used in ride-sharing.

**Rural/Suburban:** Excise tax is larger source of motor vehicle funding (84% to 97%), but may not see large decline in excise tax, because private ownership of AVs more likely.

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# PROJECTED IMPACT: AVS AND STATE REVENUE SOURCES

## Fuels Tax:

- 🚕 Will be slightly higher as a result of increase in VMT (at 20% market penetration).
- 🚕 Significantly increased (at 100%), unless there is significant ride-sharing.
- 🚕 If fleet is electric, fuels tax will decrease (at 20%) and plummet (at 100%).

## MV Sales Tax:

- 🚕 Pulled up due to higher cost (private ownership)
- 🚕 Pulled down due to reduction in vehicles (ride-sharing), but larger turn over mitigates or makes up for it.

## Tolls:

- 🚕 Increase due to higher VMT (at 20%).
- 🚕 Large increase (at 100%).
- 🚕 Small increase for ride-sharing.

## RMV fees:

- 🚕 Increase (private ownership).
- 🚕 Decrease (ride-sharing).

## Moving violations:

- 🚕 Significant decrease (at 20%).
- 🚕 Elimination (at 100%).

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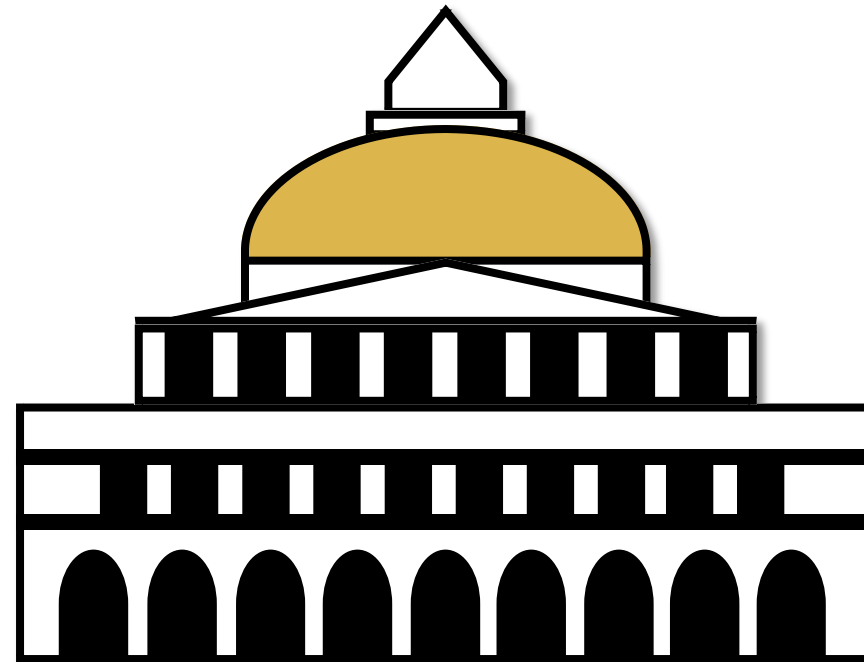
# Projected Economic Impacts: The costs and Benefits of AVs

**Congestion**: Increased traffic will cost consumers, businesses, and government between $375M to $750M (at 20%) annually and $3.7B/year (at 100%).

**Greenhouse Gases**: In the short term, GHG will cost an estimated $28M annually. In the longer term an increase in GHG will cost about $113M per year.
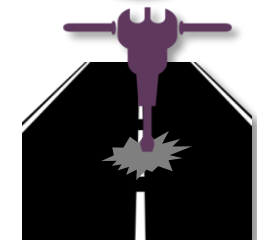
**Air pollution**: Another $30M/year can be expected in the short term from air pollution and $144M/year at 100% market penetration.

**Safety**: $660M annual (at 20%) and $3.3B (at 100%)

**Road Maintenance**: $10 to $42M at 100%.

# LESSONS LEARNED

- **No tradeoff necessary** between different economic impacts (e.g., can improve safety, traffic, and GHG at the same time).

- Tradeoff between **negative fiscal** and **positive economic impacts** can be avoided (e.g., replace gas tax and reap benefits from electric vehicles).

- AV analyses need to keep benefits of self-driving technology separate from **independent improvements in automobile technology** (e.g., fuel economy, electric vehicles, sharing, and safety).

- Huge difference in fiscal and economic impacts between **ride-hailing** and **ride sharing**.

- An increase in VMT, continued use of the ICE and private ownership a **disastrous combination** for air quality and GHG emissions.

- **MBTA budget could take hit** if low-cost driving pulls riders who can afford it away from the T, leaving behind those who cannot.

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# POLICY RECOMMENDATIONS

🚗 **Limits on Zero-Occupancy Vehicles**: Restrict distance zombie vehicles can travel.

🚗 **Zero-Emissions Vehicles**: Incentivize electric vehicles.

🚗 **Real Sharing**: Providing incentives for ride-sharing (over ride-hailing and private ownership).

🚗 **Replacing the Gas Tax**: introduce mileage-based fees.

🚗 **Bridge for Parking Revenue**: cities need to replace parking revenue in short term.

🚗 **Job training**: large-scale programs to retrain drivers.

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"SLOW DOWN! STOP TAIL-GATING! ◎★!# SELF-DRIVING CAR!"

**Rafael Mares**
Vice President and Program Director
Healthy Communities and
Environmental Justice
Conservation Law Foundation

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For a thriving New England


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# Autonomous Vehicles Educational Forum - Questions?

Scott Smith, Senior Operations Research Analyst
  Volpe Center/ U.S. Department of Transportation

Eric Bourassa, Transportation Director
  Metropolitan Area Planning Council

Rafael Mares, Vice President and Director, Healthy Communities and
  Environmental Justice, Conservation Law Foundation

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